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Evaluation of patients admitted to the emergency department with headache and undergoing neuroimaging

Evaluation of patients undergoing neuroimaging for headache

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Abstract
Aim: It is of great importance to differentiate the primary or secondary causes of headaches in the intensity of emergency services. The underlying causes of secondary headaches can be caused by neurological causes and may have a mortal course. In this study, it was aimed to determine red flags in neuroimaging for life-threatening secondary causes of patients who applied to the emergency department with headache complaints and underwent brain imaging.
Material and Methods: Our study was planned retrospectively and descriptively. Patients who presented to the 3rd step emergency department with headache within 10 years were included. Demographic characteristics, disease history and information, imaging information and results of the patients were recorded.
Results: In this study, the mean age of 704 patients was 48.9 (17-92) years, 62.8% of whom were female, and 99.6% of the patients presented to the department within the first 24 hours after headache. Their cranial CT scans identified intracranial pathologies in 19.2% (n=139) of the patients. Intracranial pathologies were detected in 27.5% who experienced the most severe headache in their life, in 31.7% who had a sudden headache, in 52.9% who had focal neurological deficits, in 23.8% who were older than 50 years old, and in other headache reasons.
Discussion: In the study on the elimination of secondary headaches in the emergency room, we concluded that having the most severe headache ever, sudden onset, neurological deficit, and being over 50 years of age are warning criteria. Although brain CT scans are generally used in clinically suspicious situations, MRI should also be used for mortality and morbidity in these patients.

Keywords
Headache, Neuroimaging, Emergency, CT

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Introduction

Headache is one of the most common complaints in the society and the emergency department [1]. According to the Headache Classification Committee of the International Headache Society (IHS), headaches are divided into two categories as primary and secondary. Most of the headaches are primary headaches [2]. Patients are admitted to the emergency department largely due to primary headaches. Migraine or stress-type headaches are the most frequently observed primary headaches. It may be often challenging to distinguish between primary and secondary headaches [3]. It is of great importance to distinguish between life-threatening secondary headaches and benign primary headaches (migraine, cluster, tension-type headaches) in a hospital emergency department full of patients. Since the underlying causes of secondary headaches can be fatal and lead to neurological deficits, a thorough medical history and detailed physical examination are the keys to evaluation. While patients admitted to the emergency department with primary headache are often conservatively treated, secondary headaches may be due to underlying structural, infectious or vascular causes. They are life-threatening in the absence of fast diagnosis [4].

The patients presenting with acute headache to the emergency department in the American College of Emergency Physician (ACEP) in 2009 were categorized under four specific groups based on whether they required neuroimaging. These groups included patients with new sudden-onset severe headache, with focal neurological deficit and altered mental status, HIV-positive patients and patients with other immunodeficiency, and patients older than 50 years with a new type of headache, but with a normal neurological examination [5]. Sudden and severe headache, different from other headaches, recent seizures or altered mental status, headache in age above 50, history of immunosuppressive therapy may be risk factors; abnormalities in physical examination and neurological examination, toxic complications and papilledema are signs of secondary headaches [6]. The decision for neuroimaging should be made to exclude the causes of secondary headaches, and appropriate imaging techniques are important for the confirmation of diagnosis and organizing the treatment plan [3]. The most commonly used imaging methods are computed tomography (CT) and magnetic resonance imaging (MRI) scans [7]. This study seeks to evaluate the patients who presented to the emergency department with headache and underwent neuroimaging and to determine the red flags which may be the neuroimaging indicators of life-threatening secondary headaches.

Material and Methods

Following the approval of the ethics committee, the records of the patients with headache (age ≥ 16 years) and those of the patients who underwent neuroimaging were evaluated in Hacettepe University archives retrospectively for 10 years (2001-2011). Data were obtained from the hospital records and the automation system. The demographic characteristics of the patients and neuroimaging indications (most severe headache that one has ever had, one's first headache, sudden onset, focal neurologic findings, change in character of pain, increased severity of pain, resistance to analgesia, patient's age ≥ 50 years) were recorded. After consultation and follow-up in the emergency department, hospitalization ratios in the ward or intensive care unit, neuroimaging reports were analyzed. Patients who had cranial CT at external centers and had trauma were excluded from of the study.

Statistical analysis

In the analyses, descriptive statistics of mean and standard deviation, minimum and maximum were used for numerical data, while number and percentage were given for qualitative data. The two-way significance test (t-test), chi-square analysis, Fisher's chi-square analysis and the McNemar test were used in the correlations between categorical data.

In all statistical tests, $p<0.05$ was accepted as significantly different and data were analyzed using the SPSS 20.0 program.

Results

A total of 1007 patients were admitted to the emergency department during the study period. After excluding the patients who had a cranial CT at an external center and had trauma, statistical analysis was performed with the remaining 704 patients. The mean age of the patients was 48.9 (17-92) years; 62.8% (n=442) of whom were female and 37.2% (n=262) were male. The average age was 48.08 (±15.674) years in male patients and 49.37 (±16.065) years in female patients, and there was no difference. In the vital evaluations of the cases applied to the emergency service, mean systolic blood pressure was 135.80 ± 29.46 (70-260) mmHg, mean diastolic blood pressure was 84.34 ± 17.39 (40-170) mmHg, mean pulse was 79.25 ± 14.35 (40-164) beats / min, mean respiratory rate was 18.61 ± 2.28 / min, mean temperature measured was 36.46 ± 0.63 (34.6-39.7) °C and mean saturation was 98.48 ± 1.87 (87 -100). It was found that the patients who were admitted to the emergency department with headache and underwent neuroimaging suffered from a headache for an average of 4.12 (±4.995) hours until they first presented to the emergency department, and 99.6% of the patients presented to the emergency department within the first 24 hours after the onset of headache (Figure 1).

The most common symptoms accompanying headaches were nausea (46.30%) and vomiting (33.20%) (Figure 2).

After studying the medical histories of the patients, it was revealed that 37.1% (n=261) of the patients had hypertension, 11.4% (n=80) of them underwent previous intracranial surgery, 10.9% (n=77) suffered from diabetes mellitus. The patients were examined for a history of previous intracranial surgery; 11.4% (n=80) of them had a history of surgery. Among those with a history of surgery, intracranial masses were the most common cause, accounting for 6.3% (n=44). When the patients were asked about a history of headache, 29% (n=209) had a previous history of headache. Headache in 6.4% of them was triggered by primary causes, whereas in 23.7% of cases, headache was led by secondary causes. At the same time, 69.9% of the patients had not been diagnosed with headache before. When we look at headache in two different groups as primary and secondary headache, the most common cause of primary headache was migraine, accounting for 5.8% (n=41), and for secondary headache, it was intracranial mass, accounting for 9.5% (n=67) (Table 1).

Table 1. Common causes of headache

Headache Type	Number	Percentage (%)
Primary causes	45	6.4
Migraine	41	5.8
Cluster	2	0.3
Other	2	0.3
Secondary causes	157	23.7
Subarachnoid hemorrhage	32	4.6
Epidural	1	0.1
Subdural	13	1.8
Intracranial mass	67	9.5
Hydrocephalus	2	0.3
Aneurysm	43	6.1
Other	9	1.3
Undiagnosed	502	69.9
Total	**704**	**100**

Figure 1. Time elapsed until admission to the emergency service

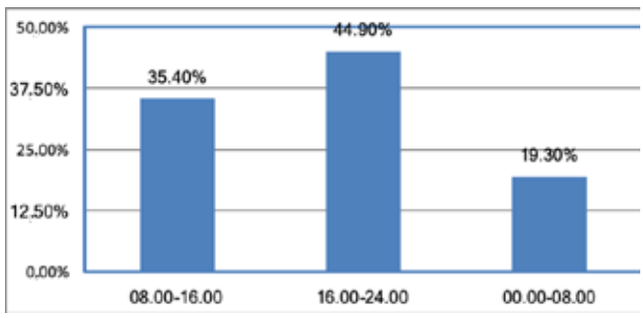
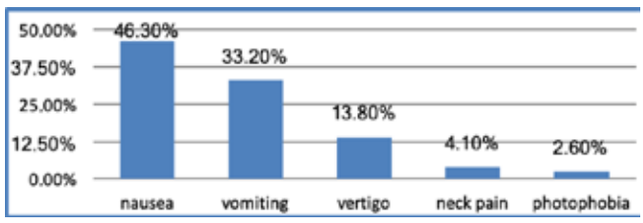


Figure 2. Symptoms accompanying headache



When the patients were asked whether they used any medication for headache, 80.8% (n=569) of them responded that they did not use any medication, while 19.3% (n=135) reported that they used medication, and nonsteroidal anti-inflammatory drugs were the most commonly used medication (Table 2).

The most common presenting complaints to the emergency department were nausea (46.3%, n=326), vomiting (33.2%, n=234), vertigo (11.3%, n=79), photophobia (2.6%, n=18), sonophobia (1.4%, n=10), phonophobia (1.1%, n=8), neck pain (4.1%, n=29). The complaints of the patients who admitted to the emergency department with headache and underwent neuroimaging (nausea, vomiting, vertigo, neck pain, photophobia, sonophobia, phonophobia) were compared considering primary and secondary causes, and no significant difference was found. The assessment of the neurological symptoms revealed that 101 out of 704 patients (14.3%) had focal neurological symptoms. Table 2 shows the distribution of neurological examination results of the patients who underwent neuroimaging by number and percentage.

The results of the cranial CT reports in the cases who underwent neuroimaging show that 19.7% (n=139) of the patients had pathology. Table 2 presents the cases with pathologies and outcomes of the patients.

Table 2. Distribution of medication used for headache, neurological examination results, cranial CT reports and outcomes by number and percentage

Parameters	Number	Percentage (%)
Drugs used for Headache		
Paracetamol	47	6.7
Nonsteroidal anti-inflammatory drugs	56	8.0
Antimigraine	2	0.3
Antiepileptic	26	3.7
Other	4	0.6
Neurological examination		
Usual examination	603	85.7
Glasgow coma scale <15	14	2
Abnormal fundus	0	0.0
Presence of cranial nerves pathology	0	0.0
Visual field impairment	5	0.7
Signs of meningeal irritation	22	3.1
Lateralize loss of strength	33	4.7
Lateralize loss of sense	10	1.4
Ataxia	25	3.6
Dysarthria	7	1.0
Romberg	1	0.1
CT Reports		
Normal	565	80.3
Subarachnoid haemorrhage	29	4.1
Intracerebral haemorrhage	13	1.8
Subdural haemorrhage	7	1.0
Intracranial heamorrhage	45	6.4
Hydrocephalus	4	0.6
Aneurysm	8	1.1
Infarcts	21	3.1
Intracranial hypotension	1	0.1
Ventriculomegaly	2	0.3
Cerebral edema	7	1.0
Sinus vein thrombosis	1	0.1
Abscess	1	0.1
Outcome		
Discharged from ED	572	81.3
Admission to ward	81	11.5
Admission to intensive care	19	2.7
Exitus	3	0.4
Discharge by own request	28	4.0
Left without permission	1	0.1
Total	704	100

Table 3. Comparison of indications for neuroimaging in brain CT

Indications for neuroimaging			Pathology Result in CT		P Value	Odds Ratio	95% Confidence Interval		Effect Size (Φc)
			No	Yes			Lower	Upper	
The most severe headache one has ever had (TMSH)	No	f	457	98	0.007*	1.770	1.163	2.696	0.10
		TMSH%	82.3%	17.7%					
		Pathology %	80.9%	70.5%					
	Yes	f	108	41					
		TMSH%	72.5%	27.5%					
		Pathology %	19.1%	29.5%					
First headache (FH)	No	f	554	138	0.477	0.365	0.047	2.851	0.038
		TMSH%	801.%	19.9%					
		Pathology %	98.1%	99.3%					
	Yes	f	11	1					
		TMSH%	91.7%	8.3%					
		Pathology %	1.9%	0.7%					
Sudden headache (SH)	No	f	524	120	0.015*	2.024	1.134	3.611	0.10
		TMSH%	81.4%	18.6%					
		Pathology %	92.7%	86.3%					
	Yes	f	41	19					
		TMSH%	68.3%	31.7%					
		Pathology %	7.3%	13.7%					
Focal Neurological Symptoms (FNS)	No	f	533	103	<0.001*	5.822	3.458	9.800	0.27
		TMSH%	83.8%	16.2%					
		Pathology %	94.3%	74.1%					
	Yes	f	32	36					
		TMSH%	47.1%	52.9%					
		Pathology %	5.7%	25.9%					
Change in character of pain (CCP)	No	f	512	124	0.614	1.169	0.638	2.142	0.02
		TMSH%	80.5%	19.5%					
		Pathology %	90.6%	89.2%					
	Yes	f	53	15					
		TMSH%	77.9%	22.1%					
		Pathology %	9.4%	10.8%					
Increased severity of pain (ISP)	No	f	382	86	0.199	1.286	0.875	1.891	0.05
		TMSH%	81.6%	18.4%					
		Pathology %	67.6%	61.9%					
	Yes	f	183	53					
		TMSH%	77.5%	22.5%					
		Pathology %	32.4%	38.1%					
Resistance to Analgesia (RA)	No	f	489	124	0.402	0.778	0.432	1.401	0.03
		TMSH%	79.8%	20.2%					
		Pathology %	86.5%	89.2%					
	Yes	f	76	15					
		TMSH%	83.5%	16.5%					
		Pathology %	13.5%	10.8%					
Patient's age ≥ 50 years (A)	No	f	321	63	0.015*	1.587	1.093	2.305	0.09
		TMSH%	83.6%	16.4%					
		Pathology %	56.8%	45.3%					
	Yes	f	244	76					
		TMSH%	76.3%	23.8%					
		Pathology %	43.2%	54.7%					

* p<0.05, Chi-square analysis, Φc = effect size

CT results were examined in terms of the relationship with pathology, with the most severe headache (SCPA). There was a significant correlation between SCBA and CT pathology results (p=0.007). While the CT pathology negative number of patients without SCBA complaints was 457, the number of CT pathology negative patients who reported SCBA complaints was 108. Although the calculated Odds ratio is 1.770, the 95% lower confidence interval did not fall below 1.

In this case, not reporting a complaint to SCPA increases being pathology negative, reporting a complaint to SCPA increases being pathology negative 1.7 times. The effect size of the chi-square analysis calculated for this relationship was determined as 0.10. According to Cohen's [8] classification, this effect size is small. In this case, it can be interpreted that CT imaging should not be requested in the first place for patients who do not report the most severe headache complaint.

The CT result of the first headache (IBA) and the emergency department admission was examined in terms of the relationship with pathology. This relationship was examined with the chi-square Pearson Exact value. Since the expected frequency in one of the pores has fallen below 5%, there is no significant relationship between IBA and CT pathology results (p>0.05, p=0.477).

The CT results on admission to the emergency service with sudden headache (ABA) were examined in terms of the relationship with pathology. There was a significant relationship between ABA and CT pathology results (p <.05, p = 0.015). While the number of CT pathology negative patients without ABA complaint was 524, the number of CT pathology negative patients reporting ABA complaint was 41. Although the calculated Odds ratio is 2.024, the 95% lower confidence interval did not fall below 1. In this case, not reporting ABA complaints increases being pathology negative, and reporting ABA complaints increases being pathology negative 2 times. The effect size of the chi-square analysis calculated for this relationship was determined as 0.10. This effect size is of small effect size. In this case, it can be interpreted that CT imaging should not be requested in the first place for patients who do not report sudden headache complaints.

Focal neurological findings (FNF) and CT results on admission to the emergency department were examined in terms of the relationship with pathology. There was a significant relationship between FNF and CT pathology results (p=0.0001). While the number of CT pathology negative patients without FNF complaint was 533, the number of CT pathology negative patients reporting FNF complaint was 32. Although the calculated Odds ratio was 5.822, the 95% lower confidence interval did not fall below 1. In this case, not reporting FNF complaints increases being pathology negative, reporting FNF complaints increases pathology negative 5 times. The effect size of the chi-square analysis calculated for this relationship was determined as 0.27. This effect size is medium effect size. In this case, it can be interpreted that CT imaging should not be requested in the first place for patients who do not report focal neurological findings.

The change in the character of pain (CCP) and the CT results at the emergency department were examined in terms of the relationship with pathology. There was no significant relationship between CCP and CT pathology results (p>0.05, p = 0.614).

The CT results were examined in terms of the relationship with pathology with increased pain severity (IPS). There was no significant relationship between IPS and CT pathology results (p>0.05, p=0.199).

Resistance to analgesia (RA) was examined in terms of the relationship with pathology on CT in the emergency department. There was no significant relationship between the name and CT pathology results (p>0.05, p=0.402).

Being under the age of 50 or over was examined in terms of the relationship with pathology on the CT result. There was a significant correlation between being under or over 50 years of age and CT pathology results (p=0.015). While the number of CT pathology negative patients under 50 years of age was 321, the number of patients over 50 years of age was 244. Although the calculated Odds ratio was 1.587, the 95% lower confidence interval did not fall below 1. In this case, pathology under 50 years of age increases being negative, and above 50 years of age increases being negative 1.5 times. The effect size of the chi-square analysis calculated for this relationship was determined as 0.09. This effect size is of small effect size. In this case, it can be interpreted that CT imaging should not be requested for patients under 50 years of age (Table 3).

Discussion

In 98% of the headache cases, presented to the ED, headaches were caused by primary causes. Secondary causes, on the other hand, lead to serious consequences [9]. To rule out secondary headache, the international classification for headache by the International Headache Society (IHS) suggests looking at the causes of primary headaches [10]. In this study, migraine is the most common cause of primary headaches accounting for 5.8% (n=41), which is consistent with the literature [11]. Headaches in this study were led by secondary causes in 23.7% of cases and mostly caused by intracranial mass in 9.5% (n=67). The results of this study were consistent with the literature. In the study conducted by Rizos et al., the rate of admission to the emergency department in the first 24 hours after the onset of headache was 52.7% [12]. Similarly, in this study, 99.6% of the patients admitted to the emergency department after the onset of headache. The highest rate of visits to the ED was between 16.00 – 24.00. This may be due to the fact that visits to the ED are high usually in the evening. The most common complaints accompanying headache were nausea and vomiting. A study by Lange et al. stated that these symptoms were associated with migraine [13]. Though nausea and vomiting may be associated with migraine, they can be present in secondary headaches. The most common diseases in the medical histories of the patients were hypertension, previous intracranial surgery and diabetes mellitus. A study by Vinson et al. showed that hypertension was the most common disorder in patients' histories [14]. To distinguish between primary and secondary headache, it is paramount to perform physical examination focusing on anamnesis and neurological examination. This makes it possible to identify clinical warning signs. Among these signs are sudden onset headache, increased severity of pain, patients aged 50 and over, which is ten times more risky than patients 75+ (11%), who also have more serious pathologies than patients younger than 50. It is important to question the use of anticoagulants or sedative drugs, which support the presence of lightning bolt headaches and focal neurological deficits (arterial dissection, cancer) and systemic diseases (hypertension and diabetes mellitus) [15]. This study reveals that the detection of pathological findings on CT scans of the brain of patients with the most severe headache they have ever had, sudden

onset headache, focal neurological deficits and older than 50 years through neuroimaging, is statistically different. The existing body of research shows that sudden onset headache, headache in patients 50+, the presence of abnormalities in the neurological examination are the cases of suspected secondary headache, and brain CT is recommended for these cases [16-19]. Change in headache pattern constitutes a risk factor for secondary headaches. Besides, abnormal neurological examination or focal neurological findings require a CT scan [20]. In this study, neuroimaging was performed considering these clinical warning signs. Sudden and severe onset headache is particularly important to diagnose subarachnoid hemorrhage, which is associated with significant morbidity and mortality [21]. The most severe, acute onset headache and headache with increasing severity of pain indicated subarachnoid hemorrhage in this study. These situations serve as clinical warning signs requiring neuroimaging. The American College of Emergency Physicians (ACEP) recommends the use of clinical warning signs to exclude secondary causes in deciding which patient groups should undergo neuroimaging. These clinical warning signs are focal neurologic deficit with headache, new-sudden onset severe headache, and new-onset headache in those aged over 50 years even if they have normal neurologic examination. In our study, findings such as sudden onset headache accompanied by focal neurological findings, and whether it was the most severe headache ever experienced, were shown to be important clinical early warning findings. A study by Jordan et al. recommended emergency neuroimaging in the presence of "sudden-severe headache" and "abnormal finding in neurologic examination" [22]. Aygun et al. reported that using clinical warning signs in the evaluation of headaches is important in the detection of significant pathologic findings with cranial CT [23].

Due to its cost and accessibility, the first option in the emergency department would be often a brain CT scan. Clinical warning signs serve as screening tools in determining which patients with headache in the ED should undergo neuroimaging; these signs are also useful in increasing effectiveness in clinics with a high patient density in their emergency departments. The most accurate approach in the diagnostic algorithm to distinguish between primary and secondary headaches is to follow the appropriate steps by benefiting from clinical warning signs.

Limitations

This study did not include any trauma patients or patients under the age of sixteen. Also, the patients with headache who had undergone neuroimaging before their admission to the ED were excluded from this study.

Conclusion

Clinical warning signs in patients admitted to the emergency departments with headache are useful in making a rapid and accurate diagnosis, excluding the causes of secondary headache, ensuring appropriate follow-up and treatment, and also preventing the need for unnecessary neuroimaging tests, consequently, avoiding high costs. In this study, when the patients admitted to the emergency department with headache, they were questioned about the clinical warning signs such as the most severe headache ever, sudden onset of headache, presence of focal neurologic findings, and being aged 50 or higher. Their answers to these questions appear to have significance for neuroimaging indications. The use of clinical warning signs will make it easier for physicians and health staff serving in emergency departments to identify life-threatening situations in advance and will also provide convenience for patients admitted to emergency services with headaches.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

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